The reproductive biology of *Carasobarbus luteus* and *Capoeta trutta* in the Tigris River, Turkey

by

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Abstract. – This study was carried out to determine the reproductive characteristics of two species of Cyprinidae, Longspine scraper, *Capoeta trutta* (Heckel, 1843) and Mesopotamian himri, *Carasobarbus luteus* (Heckel, 1843) in the Tigris River of Turkish part. A total of 307 *C. luteus* (138 females and 169 males) and 394 *C. trutta* (269 females and 125 males) specimens were analyzed. The sex ratio for *C. luteus* and *C. trutta* was 1:1.22 females (44.95%) to males (55.05%) and 1:0.47 females (68.27%) to males (31.73%), respectively. The reproduction period was between May and July for both species. The water temperature at this period was between 21.4°C and 31°C. Results indicated that the age at first maturity in *C. luteus* was three years for both males and females, and in *C. trutta,* three years for females and two years for males. The mean estimated fecundity was 5843 ± 3554 for *C. luteus* and 5285 ± 3105 for *C. trutta*. Maximal egg diameter for *C. luteus* and *C. trutta* were 1.61 ± 0.45 mm and 0.91 ± 0.41 mm, respectively.

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Résumé. – Biologie de la reproduction de *Carasobarbus luteus* et *Capoeta trutta* (Cyprinidae) dans le fleuve Tigre, Turquie.

L'objectif de l'étude est la détermination des caractéristiques de la reproduction de deux espèces de poissons de la famille des Cyprinidés, *Carasobarbus luteus* (Heckel, 1843) et *Capoeta trutta* (Heckel, 1843) vivant dans les eaux du Tigre de la partie Turque. Au total, 307 *C. luteus* (138 femelles et 169 mâles) et 394 *C. trutta* (269 femelles et 125 mâles) ont été analysés. Le sex-ratio pour *C. luteus* et *C. trutta* était de 1 : 1,22 femelles (44,95%) comparé aux mâles (55,05%) et 1 : 0.47 femelles (68,27%) comparé aux mâles (31,73%), respectivement. La période de reproduction s'étale de mai à juillet avec une température de l'eau située entre 21,4 et 31°C. L'âge à la première maturité sexuelle chez les mâles et les femelles est de trois ans chez *C. luteus,* et de trois ans pour les femelles et deux ans pour les mâles chez *C. trutta*. La fécondité moyenne est estimée à 5843 ± 3554 pour *C. luteus* et 5285 ± 3105 pour *C. trutta*. Le diamètre de l'œuf est de 1,61 ± 0,45 mm et de 0,91 ± 0,41 mm chez *C. luteus* et *C. trutta,* respectivement.

Key words
Cyprinidae
Carasobarbus luteus
Capoeta trutta
Sex ratio
First maturity
Fecundity

Investigations on reproduction of fish are essential for a better plan conservation and management strategies of fishery resources (Ali and Kadir, 1996; Kalkan, 2008; Muchlisin, 2014) and for evaluating the impacts of environmental variability on the dynamics of fish populations (Schlosser, 1990). In addition, information on the reproductive biology of candidate species is much essential for the development of aquaculture industry (Priyadharsini *et al*., 2013).

Longspine scraper, *Capoeta trutta* (Heckel, 1843) and Mesopotamian himri, *Carasobarbus luteus* (Heckel, 1843), belonging to the Cyprinidae, have a wide distribution and are common species in Euphrates, Tigris basins, and natural and artificial lakes in Mesopotamia (Kuru, 1979; Ünlü, 1991; Coad, 2010). These two species were chosen because they are among the most economically important and abundant species in the region. Observations at fish markets and incidental sampling in various waters would indicate that *Luciobarbus mystaceus* (Pallas, 1814), *Carasobarbus luteus*, *Capoeta trutta*, *Capoeta umbla* (Heckel, 1843) and *Acanthobrama marmid* Heckel, 1843 constitute about 60 percent of the total production (FAO, 2014).

There have been some studies on the reproductive characteristics, such as sex ratio, spawning time, fecundity and age at first maturity of both *C. trutta* and *C. luteus* in the Tigris and Euphrates River systems in Turkey (Ünlü, 1991; Duman, 2004; Kalkan, 2008; Oymak *et al*., 2008; Düşükcan and Çalta, 2012; Canpolat and Çalta, 2013, 2014; Aral *et al*., 2014), in Iraq (Ahmed *et al*., 1984; Naama and Muhsen, 1986; Bartel *et al*., 1996; Rahemo and Al-Shatter, 2012), in Iran (Patimar and Farzi, 2011; Eydizadeh, 2014; Poria *et al*., 2014) and in Syria (Al-Hazzaa and Hussein, 2003; Al-Hazzaa, 2005). However, research on biology of *C. trutta* in the Tigris River in Turkey was realized before dams were constructed. Many environmental changes have occurred due to start of dam activities. Besides, there is no study on reproduction of *C. luteus* population in the upper part of the

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Figure 1. – *Capoeta trutta* (**A**) and *Carasobarbus luteus* (**B**), specimens captured in the Tigris River in Turkey.

Tigris River in Turkey. The Tigris River and its tributaries are spread over a wide geographical area, showing climatic differences in populations of these species in Tigris River and these parts of Turkey differ from those of Iraq, Iran and Syria (Patimar and Farzi, 2011). Thus, knowledge on the reproductive characteristics is critical for understanding the future of the species due to environmental changes. Therefore, this study was carried out to determine the reproductive characteristics, including sex ratio, age at first sexual maturity, spawning time, gonadosomatic index, ova diameter and fecundity, of both *C. luteus* and *C. trutta* in the Turkish part of the Tigris River.

MATERIALS AND METHODS

Samples of *Capoeta trutta* and *Carasobarbus luteus* (Fig. 1) were identified with the identification keys developed by Kuru (1980) and Coad (2010). They were collected monthly from Tigris River near Bismil Town of Diyarbakır in Turkey, from April 2012 to May 2013. The station was located at a latitude of 37°50'18"N, a longitude of 40°36'18"E and an altitude of 545 m. Overall, 307 *C. luteus* and 394 *C. trutta* specimens were collected from this site by using gill nets of various mesh size (18 x 18 mm, 24 x 24 mm and 30 x 30 mm). Specimens were immediately transported to the laboratory in a portable icebox. Water temperature, dissolved oxygen, pH and electrical conductivity were measured in the field by multiparameter equipment (Hache Lange marka HQ40) to measure four physico-chemical parameters of the studied station (Tab. I).

Fork length (FL), weight (W) and gonad weight (GW) were measured to the nearest 1 mm, 1 g and 0.01 g, respectively. Sex in mature specimens was easily defined from macroscopic gonadal observations, but microscopic examination was used for differentiating sex in juveniles (Ünlü, 1991; Gökçek and Akyurt, 2008). The sex-ratio, determined on all samples and by month, was statistically tested for significant deviations from the expected 1:1 ratio with a χ^2 test (Fehri-Bedoui and Gharbi, 2008). Differences were considered statistically significant at $p < 0.05$. Age was determined from scales (Polat, 1987; Aydin *et al*., 2003; Gökçek and Akyurt, 2008; Baboli and Sayahi, 2014). For this purpose, approximately 10 scales from each fish were taken from the right side of the body, between the lateral line and dorsal fin. Scales were placed in 5% KOH solution to remove its tissue. They were then washed, dried and mounted between two glass microscope slides. The criteria of Chugunova (1963) were followed for annulus identification. Every scale was read twice by Kindermann microfiche reader.

Maturity of samples was determined by visual inspection of the gonads in the samples caught in months close to the reproductive period. The age at which 50% of fish were mature was considered to be age at first maturity for both sexes (Oymak *et al*., 2011). The average length recognized as this age was considered to be the length at first maturity. The monthly gonadosomatic index (GSI) was used to determine the spawning period following the formula GSI = Gonad weight (GW) × 100 Body weight (W) – Gonad weight (GW), given by Franks *et al*. (1998), Jobling *et al*., (2002), and Porter and Janz (2003).

Absolute fecundity (F) was estimated gravimetrically (Laevastu, 1965; Tesch, 1968) on the study of mature ovaries of samples taken before the spawning season (April and May). Relative fecundity (RF), based on gonad-free somatic weight was estimated by RF = F / (W – GW), where F = absolute fecundity, or the total number of eggs per female; W = total weight; and GW = gonad weight (Bobko and Berkeley, 2004).

Table I. - Four physico-chemical properties of water taken monthly from studied locality from April 2012 to May 2013.

	2012									2013				
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Temperature (°C)	13.0	21.0	31.0	27.0	25.8	24.0	18.0	10.0	8.3	9.3	11.0	11.8	13.0	24.0
O_2 (mg/l)	7.8	4.0	5.7	4.4	2.3	5.6	4.7	5.9	9.4	8.0	7.6	8.8	6.9	4.2
pH	8.1	7.6	7.8	7.7	7.6	7.7	7.1	7.4	8.1	8.0	7.8	8.1	8.0	7.7
Conductivity (μS/cm)	318	382	385	375	383	389	395	448	371	423	432	367	337	364

Mean ova diameter was estimated monthly by randomly selecting approximately 5 to 10 eggs from each female, and measures were performed by NIS-Elements D software using a Nikon ECLIPSE 80i microscope. Regression equations describing relationships between fecundity-fork length, body weight and gonad weight were calculated by the following formulas:

LogF = Loga + bLogFL;

LogF = bLogW;

LogF = Loga + bLogGW

where F = number of eggs, FL = fork length (mm), W = body weight (g) and GW = gonad weight (g) (Ünlü *et al*., 1994; Oymak *et al*., 2011).

RESULTS

Sex ratio

A total of 307 *Carasobarbus luteus* (138 females and 169 males) and 394 *Capoeta trutta* (269 females and 125 males) specimens were analyzed. This ratio was 1:1.22 females to males for *C. luteus* and 1:0.47 females to males for *C. trutta* (Tab. II). The overall ratio was not significantly different from 1:1 for *C. luteus* ($\chi^2 = 3.130$, $p > 0.05$), whereas a significant difference for *C. trutta* was found ($\chi^2 = 52.629$, $p < 0.01$). Monthly variations in sex ratio were also noted. The sex ratio of *C. luteus* was significantly different from 1:1 (χ^2 test, $p < 0.05$) in March and August 2012 as well as in May 2013, with more males than females. In contrast, in *C. trutta*, females predominated the catch in all months during the study except May 2012 and April 2013 and the sex ratio was significantly different from 1:1 (χ^2 test, $p < 0.05$) (Fig. 2).

Age and size at first maturity

The maturity status of the individuals of *C. luteus* and *C. trutta* used in this study are given in table III. *C. luteus* females and males reach sexual maturity at the age of three in the studied samples. The smallest mature female and male fork lengths were 108 mm and 110 mm, respectively. Sexual maturity, age and length were determined for *C. trutta,* as follows: three years and 18.2 cm length for females and two years and 13.8 cm length for males.

Spawning season

Monthly fluctuations in GSI and oocyte diameter variation of *C. luteus* and *C. trutta* used to determine the spawning season are presented in figure 3. Observed annual changes of GSI in *C. luteus* peaked in May (females: 12.5%, males: 9.4%) then dropped drastically from June and July for both males and females because almost all individuals had reproduced. In *C. trutta*,

Table II. - Sex ratio of *Carasobarbus luteus* and *Capoeta trutta* according to age groups in the Tigris River from April 2012 to May 2013.

Age groups	*Carasobarbus luteus*			*Capoeta trutta*		
	Number		Ratio (F:M)	Number		Ratio (F:M)
	Females	Males		Females	Males	
I	–	–	–	1	–	1: 0.00
II	4	4	1:1.00	25	7	1:0.28
III	17	27	1:1.59	91	50	1:0.55
IV	43	88	1:2.05	104	46	1:0.44
V	48	43	1:0.90	39	21	1:0.54
VI	17	7	1:0.41	9	1	1:0.11
VII	2	–	1: 0.00			
VIII	6	–	1: 0.00			
IX	1	–	1: 0.00			
Total	138	169	1:1.22	269	125	1:0.47

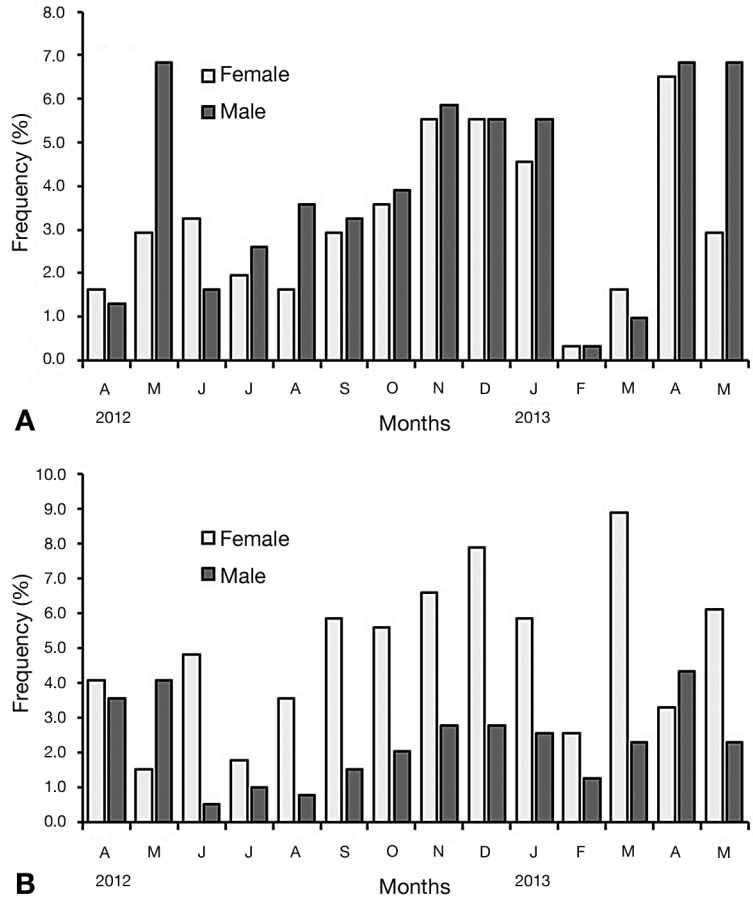

Figure 2. - Sex-ratio of *Carasobarbus luteus* (**A**) and *Capoeta trutta* (**B**), in relation to months from April 2012 to May 2013.

a similar pattern of GSI variation for females (6.44%) and males (7.98%) was found. A one-way ANOVA applied to values of GSI indicated their significant heterogeneity for *C. luteus* female ($F = 36.30$; $p < 0.001$) and male ($F = 47.11$; $p < 0.001$) and for *C. trutta* female ($F = 12.62$; $p < 0.001$) and male ($F = 18.27$; $p < 0.001$).

A similar trend between GSI values and egg diameter was found throughout the year. In *C. luteus* and *C. trutta*, the mean egg diameter reached its maximum size in May (1.61 ± 0.45 mm and 0.91 ± 0.41 mm, respectively), while its minimum size was measured in August for *C. luteus* (0.24 ± 0.05 mm) and in October for *C. trutta* (0.17 ± 0.05 mm).

According to the GSI values, seasonal development in ovary size, and through direct observation of the gonads, it is concluded that the spawning took place in May and extended to June in both *C. luteus* and *C. trutta* populations.

Table III. - Percentage of mature individuals of *Carasobarbus luteus* and *Capoeta trutta* in relation to age groups in the Tigris River from April 2012 to May 2013. N: Number of fish; IM: Immature; M: Mature.

Carasobarbus luteus	Females			Males		
	N	IM%	M%	N	IM%	M%
I	–	–		–		
II	1	100.0	0.0	4	75.0	25.0
III	5	40.0	60.0	11	18.2	81.8
IV	22	13.6	86.4	50	6.0	94.0
V	26	7.7	92.3	27	3.7	96.3
VI	13	0.0	100.0	7	0.0	100.0
VII	2	0.0	100.0	–		
VIII	6	0.0	100.0	–		
IX	1	0.0	100.0	–		
Capoeta trutta	Females			Males		
	N	IM%	M%	N	IM%	M%
I	1	100.0	0.0	–		
II	15	66.7	20.0	4	25.0	75.0
III	65	16.9	89.0	32	15.6	84.4
IV	38	5.3	96.2	27	7.4	92.6
V	21	0.0	100.0	14	0.0	100.0
VI	5	0.0	100.0	1	0.0	100.0

Fecundity

In order to determine the absolute and relative fecundity, mature females individuals obtained in April and May were used. Absolute fecundity ranged from 1672 to 14678 with a mean of 5843.69 ± 3554.95 (n = 41) in *C. luteus* and 1730 to 9227 with a mean of 5285 ± 3105 (n = 36) in *C. trutta*. Relative fecundity varied between 11.67 eggs/g and 56.60 eggs/g with a mean of 44.61 ± 22.06 for *C. luteus* and between 9.25 eggs/g and 90.83 eggs/g with a mean of 32.15 ± 19.15 for *C. trutta*.

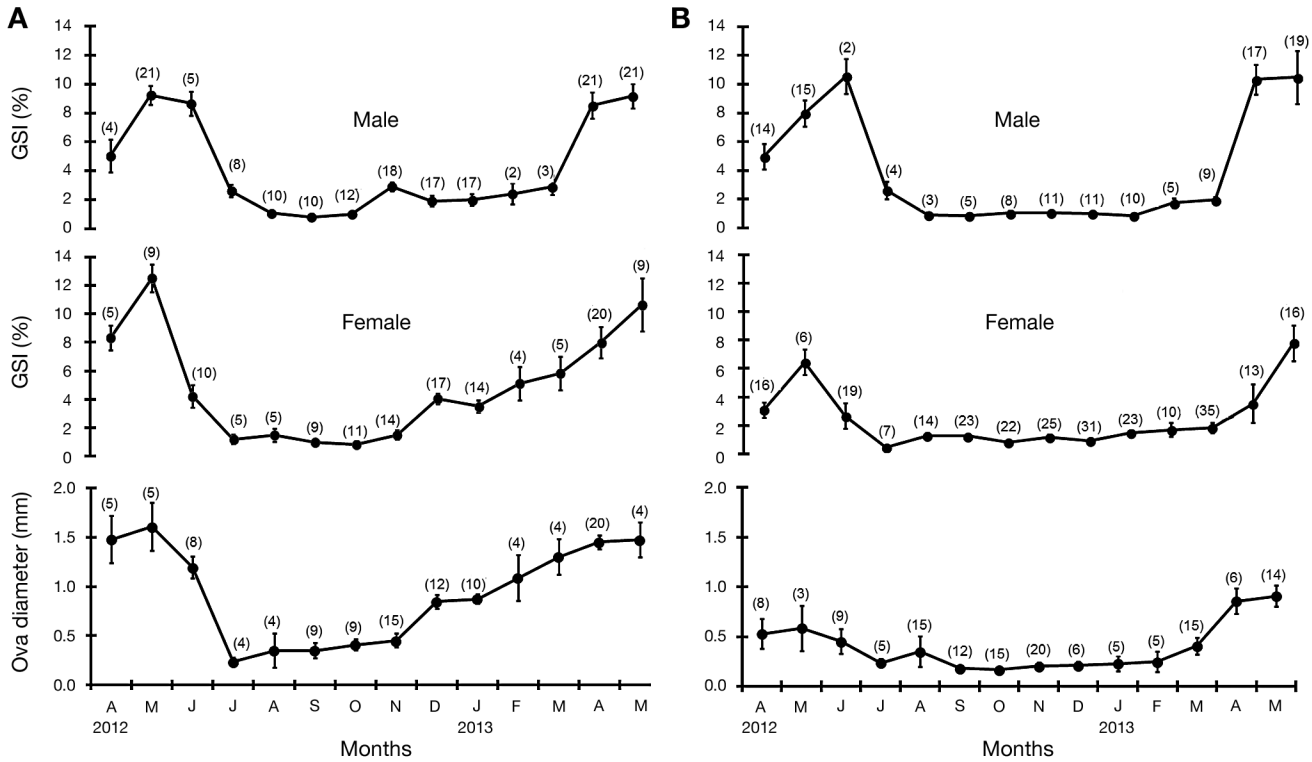

Figure 3. - Monthly gonadosomatic index (GSI) and egg diameter of *Carasobarbus luteus* (**A**) and *Capoeta trutta* (**B**) in the Tigris River in Turkey, from April 2012 to May 2013. Vertical bars: standard error of the mean; Numbers: number of samples in each month.

Table IV. - Fecundity-length-weight-gonad weight relationships of *Carasobarbus luteus* and *Capoeta trutta* in the Tigris.

	Equations	R^2	Significance
Carasobarbus luteus (n = 41)	Log F = -0.3943 + 1.7947 log FL	0.3181	P > 0.05
	Log F = 2.4250 + 0.5950 log W	0.3175	P < 0.05
	Log F = 3.3775 + 0.4384 log GW	0.3458	P < 0.05
Capoeta trutta (n = 36)	Log F = 1.582 + 0.878 log FL	0.011	P > 0.05
	Log F = 0.923 + 1.208 log W	0.169	P > 0.05
	Log F = 3.299 + 0.381 log GW	0.452	P > 0.05

Fecundity-fork length, fecundity-body weight and fecundity-gonad weight of *C. luteus* and *C. trutta* in the Tigris River are given in table IV. The correlations were positive but low in both *C. luteus* and *C. trutta*. Only body weight and gonad weight of *C. luteus* had a significant correlation with fecundity ($p < 0.05$).

DISCUSSION

Results obtained from our study showed that the females/males percentage was 44.95/55.05 or 1:1.22 ratio for *Carasobarbus luteus* and 68.27/31.73 or 1:0.47 ratio for *Capoeta trutta*. There was no significant difference in the sex ratio of *C. luteus*. Similar results were reported in other studies (Al-Hazzaa, 2005; Rahemo and Al-Shatter, 2012; Baboli and Sayahi, 2014) except records given by Eydizadeh (2014) in Hoor Al-Azim wetland. In contrast, there were more females than males in *C. trutta* and the ratio was significantly different ($p < 0.05$) from the expected ratio of 1:1. More females were also observed in different populations (Polat, 1987; Ünlü, 1991; Baboli and Niya, 2014), whereas Kalkan (2008) reported more males than females of *C. trutta* in the Karakaya dam Lake in Turkey. It is considered that sex ratio may depend on reproductive behaviour and feeding attraction of fish. It is well known that the sex ratio varies considerably from species to species, differs from one population to another of the same species, and may vary from year to year in the same population depending on fishing (Nikolsky, 1963).

C. luteus females and males reached sexual maturity at three years and the smallest size at first sexual maturity for *C. luteus* was found at 108 mm for females and at 210 mm for males. Al-Hazzaa (2005) determined that, in the Euphrates River, most of *C. luteus* matured in their second year, and all 3-year old individuals had mature gonads and were able to reproduce. Eydizadeh (2014) estimated the mean size at first maturity as 210 mm in Hoor Al-Azim wetland.

C. trutta males and females sexual maturity was observed in their second or third year of life, when they have reached a fork length of 182 mm for females and 138 mm for males. Similar results have been reported in different localities of this species (Ünlü, 1991; Kalkan, 2008; Canpolat and Çalta, 2013; Eydizadeh 2014; Baboli and Niya, 2014). Age and size at sexual maturity is a critical component of any organism because of their importance in life history. Besides, age and size at first maturity may be different in various populations (Hashemi *et al*., 2013; Eydizadeh 2014).

Both *C. luteus* and *C. trutta* reached their maximum GSI values in May, while their minimum values were in August and September, because almost all individuals had spawned. Decrease in the mean GSI values was observed in June samples, however some specimens still carried some oocytes in the gonads. The mean GSI values gradually increased from October up to the new spawning season. The highest GSI values in May and the lowest values were determined in other populations of the two species *C. trutta* and *C. luteus* (Ünlü, 1991; Kalkan, 2008; Canpolat and Çalta, 2013; Eydizadeh 2014). Ahmed *et al*. (1984) determined that, for *C. luteus*, spring was the spawning season; summer was to regain strength, and then during winter and autumn, fish prepared for the next reproductive cycle.

In this study, the mean egg number varied from 1672 to 14678 in *C. luteus* and from 1730 to 9227 in *C. trutta*. In previous studies on *C. trutta*, they were estimated as 4713-18240 in the Tigris River (Ünlü, 1991), and 1892-34432 in the Keban Reservoir (Canpolat and Çalta, 2013). The fecundity in *C. luteus* was estimated between 1729 and 38433 by Ahmed *et al*. (1984) in Al-Hammar Marsh (Iraq), and between 2455 and 26300 by Al-Hazzaa (2005) in the Euphrates River.

It has been reported that fecundity varies with fish age, length and weight and especially temperature, which is the most important ecological factor affecting egg number (Nikolsky, 1963). Bartel *et al*. (1996) defined that the fecundity of *C. luteus* was significantly lower in saltwater than in freshwater. It has also been stated that the older individuals are more productive than the younger ones (Baboli and Niya, 2014). Although absolute fecundity was high in heavier fish, the relative fecundity decreased with increase in body weight of fish. These results are in agreement with those reported by various fish species (Velazquez, 1999; Kurita *et al*., 2003; Valentin *et al*., 2015; Wagle, 2014). It has also been reported that, when the weight is closely related to the condition of the fish, fecundity is better correlated to the weight of the fish than to the length (Bagenal, 1978). In the present study, no significant correlation was observed between fecundity and length, weight and gonad weight, while fecundity-body weight and fecundity-gonad weight are positively correlated in *C. luteus*. All correlation coefficient values between fecundity with other parameters estimated in this study are lower than those given previously for *C. luteus* (Ahmed *et*

al., 1984; Al-Hazzaa, 2005) and *C. trutta* (Baboli and Niya, 2014) studied in different localities. The low values obtained from the relation of the fecundity with gonad weight are possibly due to variations in fecundity with the geographic location or time (Nikolsky, 1963) and differences in the sample size in which fecundity was observed (Lambert, 2008).

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